German Research Project SUVEREN
Safety of Urban Underground Transportation Areas considering New Energy Carriers: Objectives - Status – Results

ITA-COSUF Workshop on New Energy Carriers in Road Tunnels, 21.02.2019, Utrecht

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GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

Motivation

Dynamic increase of New Energy carrier (NEC):

Source: shutterstock.com

- Batteries
- Pressurized Gas
- Liquid Biofuels

Gap of

- **Knowledge**

  Risk and impact of NEC

- **Regulation**

  Existing, standards regarding design are based on conventional energy carriers only

BMBF Call 2016

German-French cooperation in the field „safety of future urban areas“

Project SUVEREN

Partner

BAM

FOGTEC FIRE PROTECTION

STUVA

GEFÖRDERT VOM

Bundesministerium für Bildung und Forschung

Project duration

August 2017 to July 2020

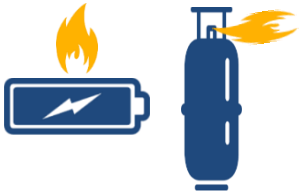
Associated Partner

- INERIS
- CETU
- DB Station & Service
- Feuerwehr München

Sub-Contractor

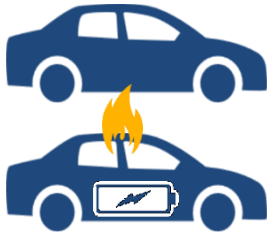
- IFAB
- INERIS Développement

Overview SUVEREN approach



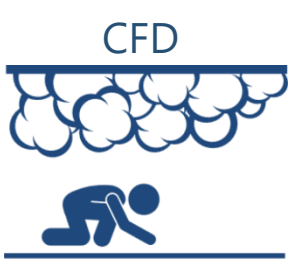
NEC

Threats



Scenarios

Case studies

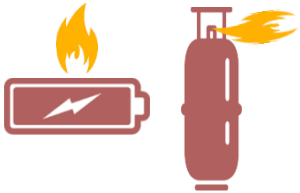


Numerical simulation

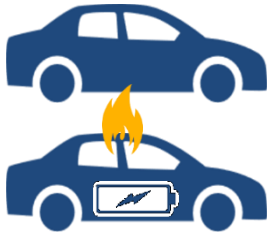
Measures

Impact on Safety

SUVEREN



NEC Threats



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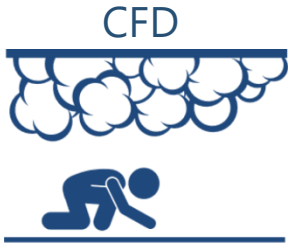


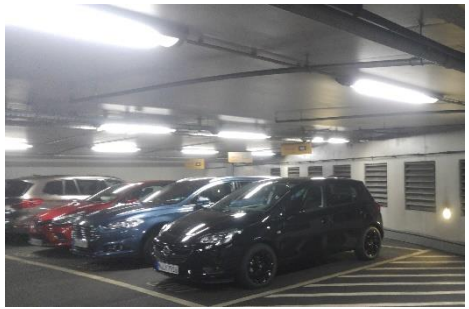
Numerical simulation

Measures

Impact on Safety

Risk assessment

- Release of toxic / suffocating gases
  - different propagation mechanisms (cold) which endanger the areas for evacuation
- NEC are high-energy fire sources, which likely lead to vehicle fires. Different fire development (in terms progression) result from
    - Thermal Runaway (Battery)
    - Jetflames (Gas)



Source: STUVA

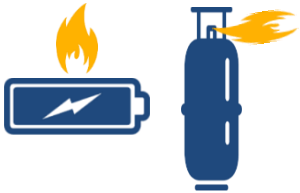
Threats of Lithium-Ionen-Batteries

- Thermal runaway due to
  - Mechanical impact (accident)
  - Thermal impact (external initial fire)
  - Incorrect operation (defect BMS, charging, short circuit)
  - spontaneous (aging, production fault)
- changed fire load and / or changed fire development
  - Depending on design, battery capacity and state of charge (SOC)
- Battery fires are difficult to extinguish (encapsulated design, chemical properties)
- Release of critical amounts of toxic substances (e.g. hydrogen fluoride, heavy metals)
- gas emission of toxic gases before fire
- Threat to fire service
  - High voltage
  - Delayed re-ignition

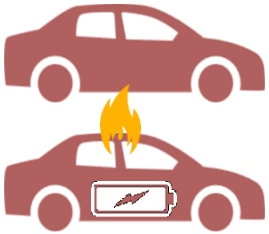
Threats of pressurized gases

- Bursting pressure vessels
- Jet flame
- Flammable mixture (deflagration, explosion)
- Oxygen displacement
- Extreme cold temperature

H_2	▪ wide ignition range with low ignition energy ▪ high pressure vessels up to 700 bar ▪ high diffusion rate ▪ almost invisible flames, flame temperature 2.000° C
CNG	▪ Gas accumulation in the ceiling area
LNG	▪ Gas accumulation in the ceiling area ▪ Puddle (extreme cold) ▪ Poolfire ▪ BLEVE
LPG	▪ Gas accumulations in deeper areas ▪ BLEVE
DME	▪ Gas accumulations in deeper areas ▪ Puddle (extreme cold) ▪ Poolfire ▪ BLEVE



NEC Threats



Scenarios

Case studies

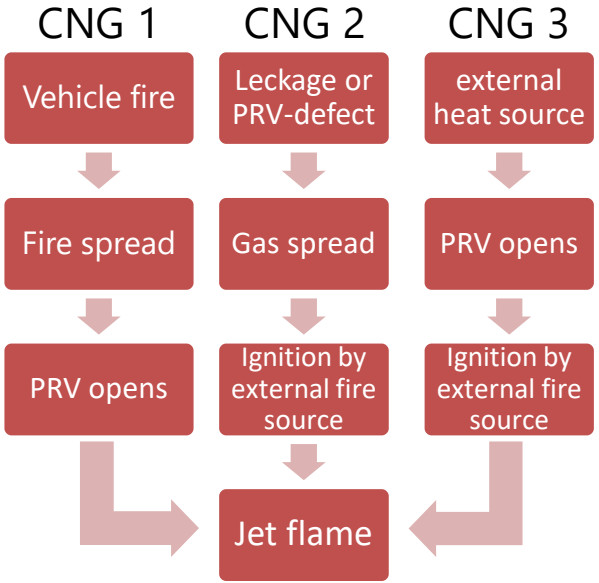
Numerical simulation

Measures

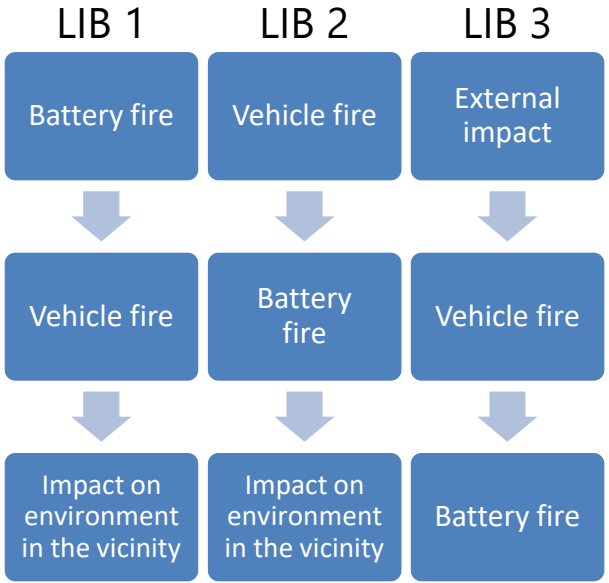
Impact on Safety

Scenarios

CNG-Scenario



LIB-Scenario

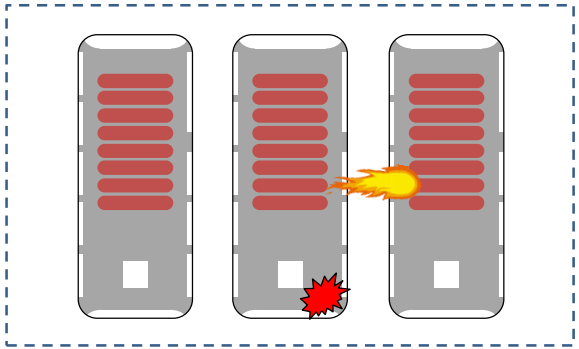


CNG Bus Fire (NL 2017)

https://youtu.be/vHf2o9oVY24

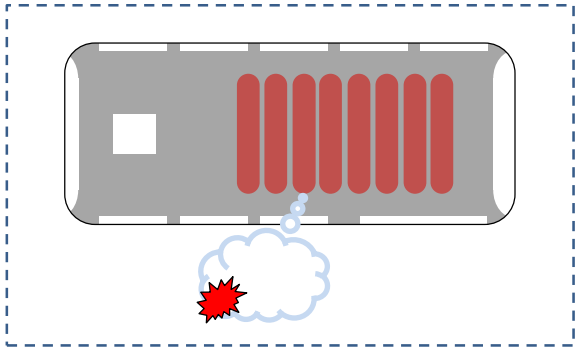
Source: Bundesanstalt für Materialforschung und –prüfung (BAM)

Examples design-scenarios - Gas



CNG Scenario I

- Buses parked close to each other (Depot)
- 3 CNG buses
- Fire spread from motor compartement of middle bus

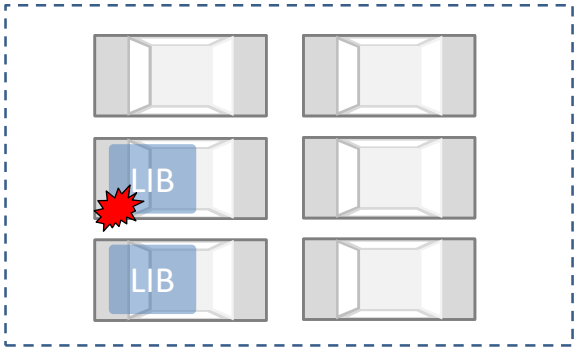


CNG Scenario II

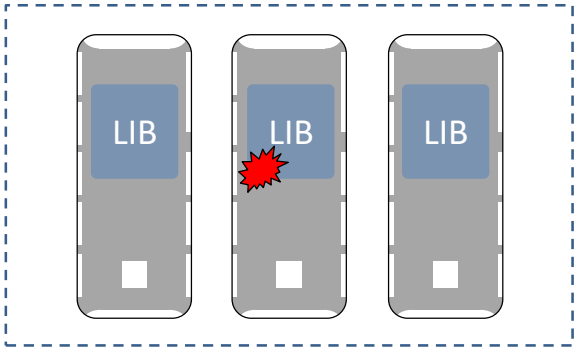
- Busdepot
- Single CNG-Bus
- Gas leakage due to defect PRV
- Ignition by external source

Source: Bundesanstalt für Materialforschung und –prüfung (BAM)

Examples design-scenarios - Battery



LIB Scenario I
- Underground carpark
- 6 vehicles, thereof 2 electrical
- Thermal runaway induces fire



LIB Scenario II
- Busdepot
- 3 electro-Buses
- Thermal runaway induces fire on the middle bus

Source: Bundesanstalt für Materialforschung und –prüfung (BAM)

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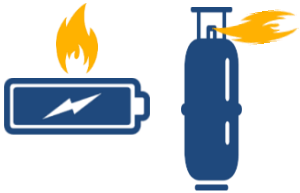

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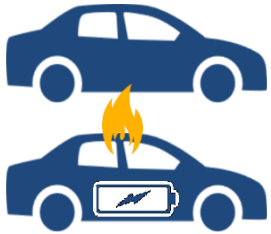
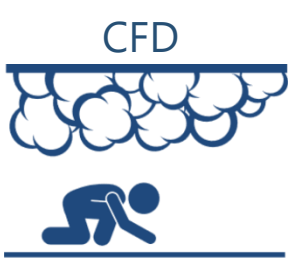
Threats



Scenarios

Case studies



Numerical simulation

Measures

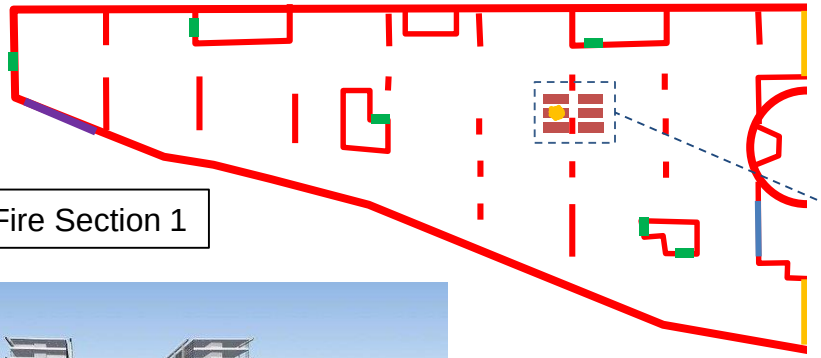
Impact on Safety

NEC in underground urban transportation areas

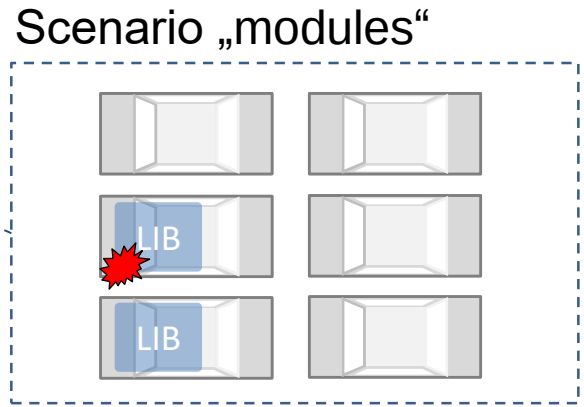
- Flowing traffic
  - Traffic tunnel (road)
  - Access tunnel (traffic area)
- Stationary traffic
  - Parking garages
  - Deliveryzones
  - Vehicle depots
- Stations and hubs

Source: Shutterstock.com, stock.adobe.com

Case study parking garage



Quelle: https://www.berlin.de/tourismus/fotos/sehenswuerdigkeiten-fotos/1355918-1355138.gallery.html?page=1



Set up for numerical simulation

Source: Bundesanstalt für Materialforschung und –prüfung (BAM)

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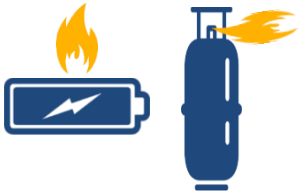

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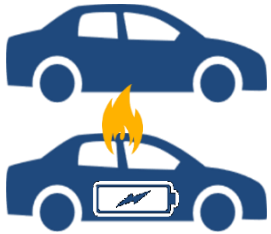

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Measures

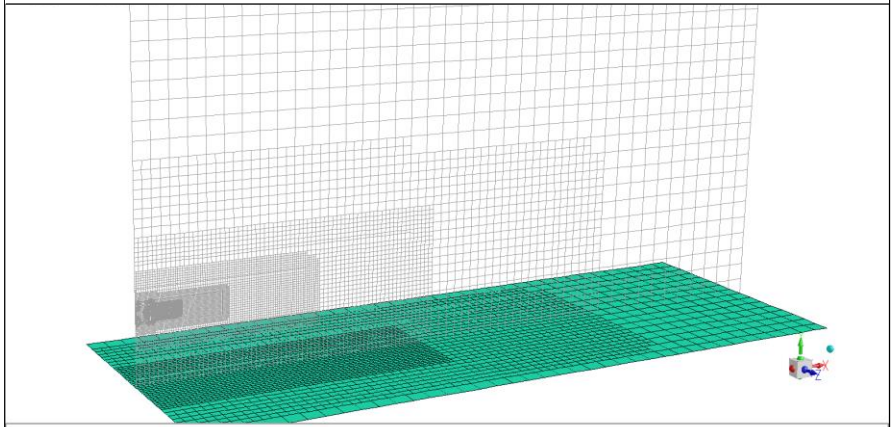
Impact on Safety

CFD-Modelling of Jetflame

Temperature

Contours of Static Temperature (k) (Time=2.5000e-04)

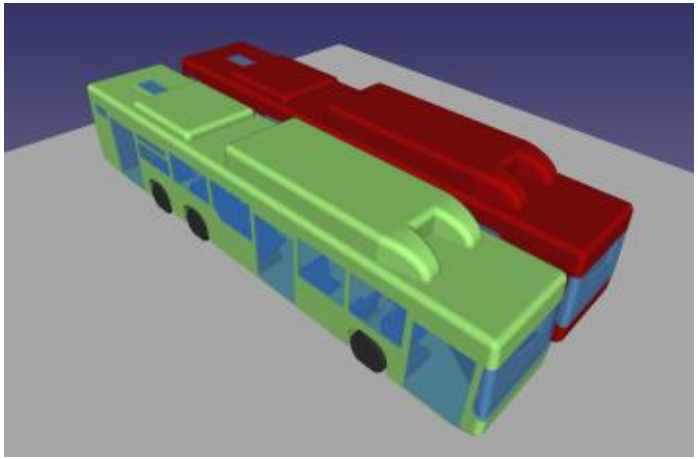
Flamme surface



Contours of Static Temperature (k) (Time=3.5000e-03)

Source: Bundesanstalt für Materialforschung und –prüfung (BAM)

CFD-Simulation



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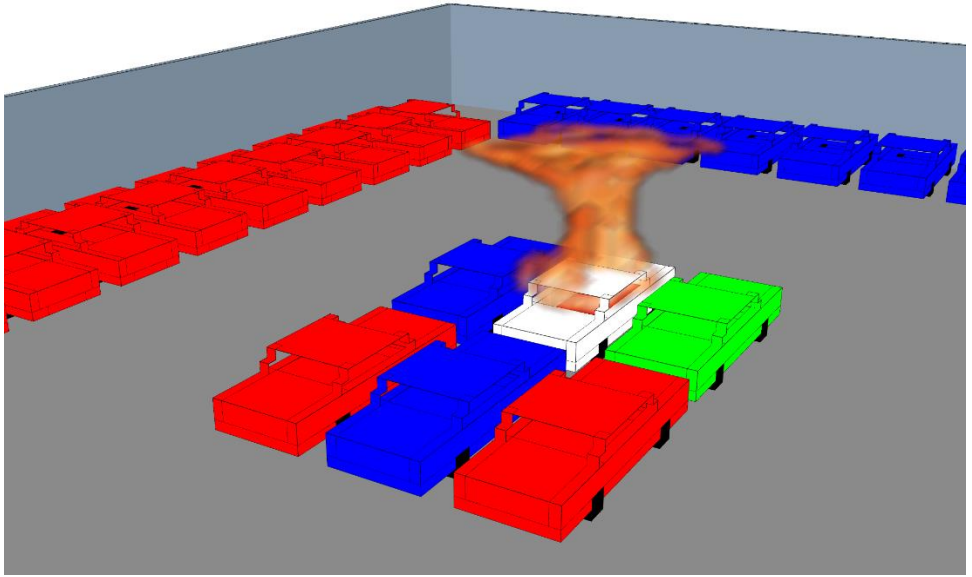

Source: FOGTEC

Evacuation simulation

- Determine the impact of NEC (based on results of CFD-calculation)
- Quantify the difference between conventional and NEC
- Develop recomendations for calculation and rescue concepts

Source: STUVA

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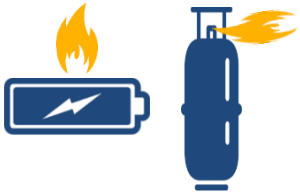

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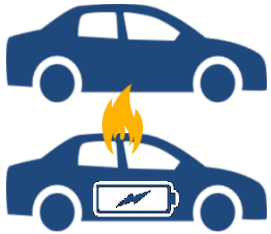

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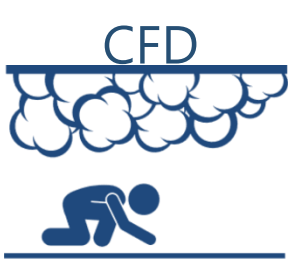


Numerical simulation

Measures

Impact on Safety

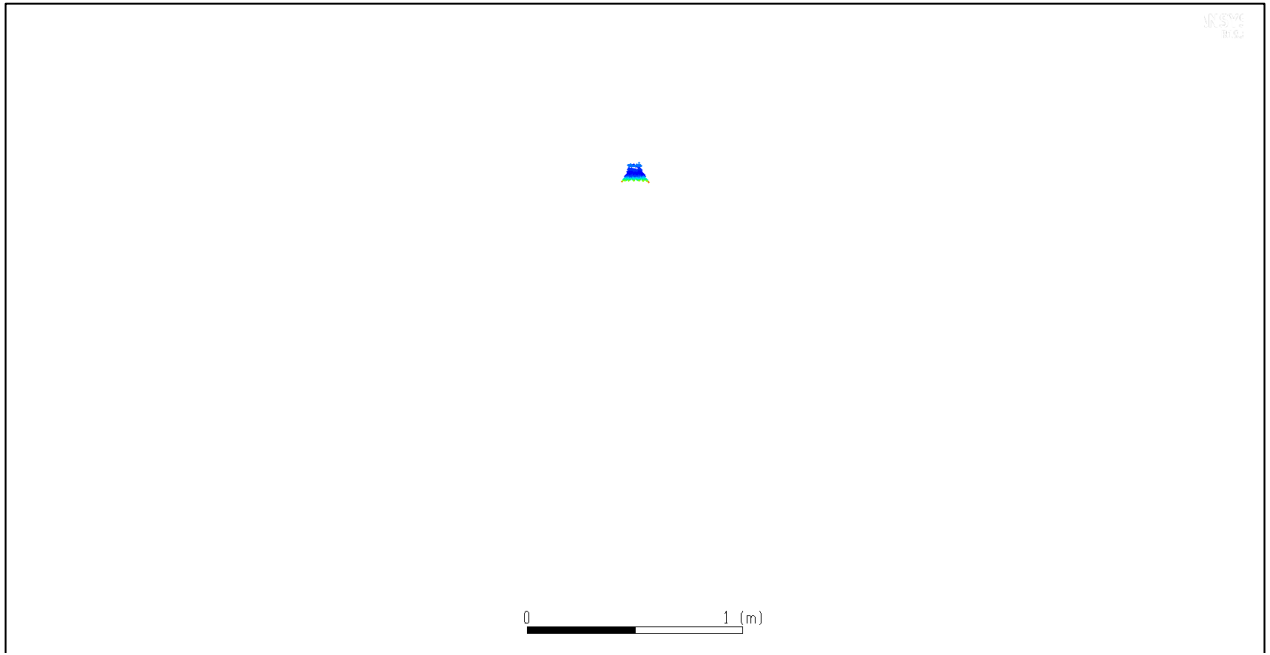
Development of measures to mitigate the impact

- Identification of appropropriate detection sensors and threshold values

- Development and proof of active measures for the reduction of the effects of NEC induced events

Source: IFAB

CFD modeling of watermist

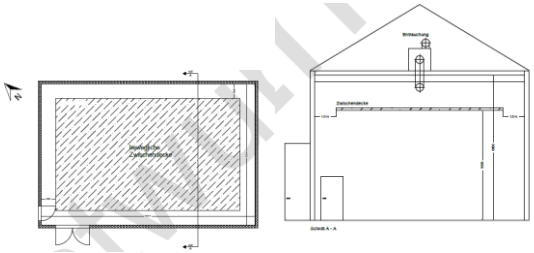


Source: Bundesanstalt für Materialforschung und –prüfung (BAM)

Large scale fire tests for calibration and validation of CFD

Test Location

DLR - Fire Test Hall (Traun, Germany)



Source: IFAB

Real scale fire tests are scheduled 25.03.2019 – 12.04.2019

Fire load

- Full size Lithium-Ion Batteries 30 kWh / 40 kWh
- CNG Jet flame
- Substitute fire load

Mock up

- Separate fire load
- Car

Measures

- Active fire fighting
- Testing of Sensors

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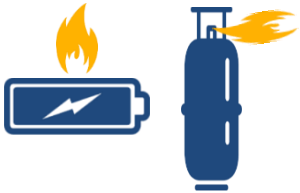

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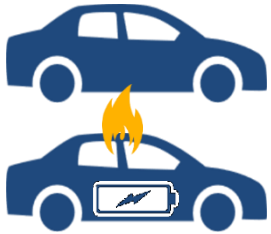

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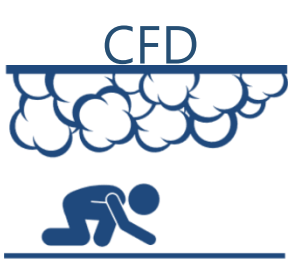


Numerical simulation

Measures

Impact on Safety

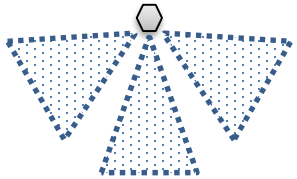
Project results

Safety concepts for underground urban areas:

- Engineering methods to calculate and to asses the risk and impact of NEC *(performance based design)*
- Recommendations for appropriate design and equipment of new and existing underground infrastructures *(best practice)*

Technologies for mitigation:

- Evaluation and validation of sensors and active measures



Project publications

- SUVEREN-Guideline (Leitfaden) providing concrete support
- Training programes for designer and operators
- Results will be used as input for standards and regulations

Thank you very much for your attention

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